# NASA ISRO (Indian Space Research Organization) Synthetic Aperture Radar: NISAR Mission Overview

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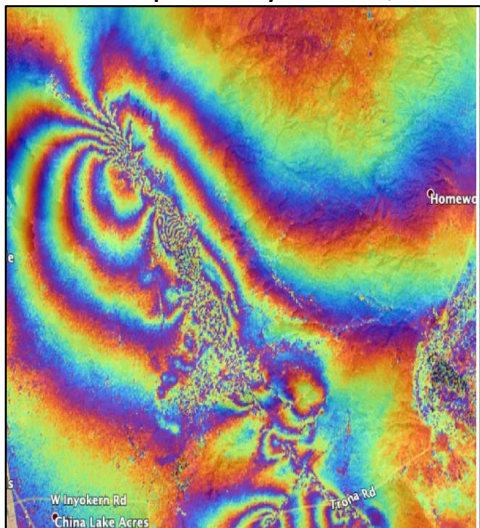NISAR Program Scientist
NASA Headquarters

**Dr. Paul Rosen**
**NISAR Project Scientist**
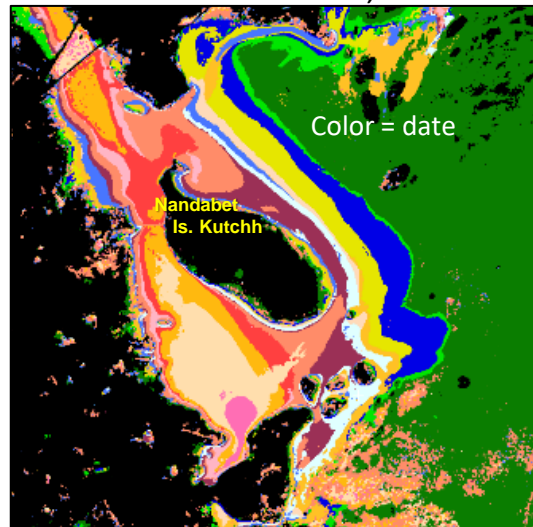Jet Propulsion Laboratory
California Institute of Technology

**NASA Biodiversity and Ecological Conservation Science Team Meeting**
**College Park, Maryland**
**May 7 -8, 2023**

# NISAR Science: Capturing a Dynamic Earth



Earthquake Dynamics, CA



Wetland Inundation, India

Color = date

Nandabet Is. Kutchh



Disaster Monitoring:
Bobcat Fire, Pasadena

NASA / JPL-Caltech / ARIA Product
Contains modified Copernicus Sentinel data (2020)
Basemap: Google, Landsat, Copernicus

## Key Scientific Objectives

**Dynamics of Ice: Ice sheets, Glaciers, and Sea Level**
- Understand the response of ice sheets and glaciers to climate change and the interaction of sea ice and climate

**Ecosystems and Biomass Change**
- Understand the dynamics of carbon storage and uptake in wooded, agricultural, wetland, and permafrost systems

**Solid Earth Deformation: Hazard Response**
- Improve knowledge for forecasts of earthquakes, volcanic eruptions, and landslides

- **Coastal Processes: India**
  - Understand the state of important mangroves
  - Understand how coastlines are changing around India
  - Determine shallow bathymetry around India
  - Assess variation of winds in India's coastal waters

## Key Applications Objectives

- Understand **societal impacts** of dynamics of water, hydrocarbon, and sequestered $CO_2$ reservoirs
- Enhance **agricultural monitoring** capability in support of food security objectives
- Apply NISAR's unique data sets to explore the potentials for **urgent response and hazard mitigation**
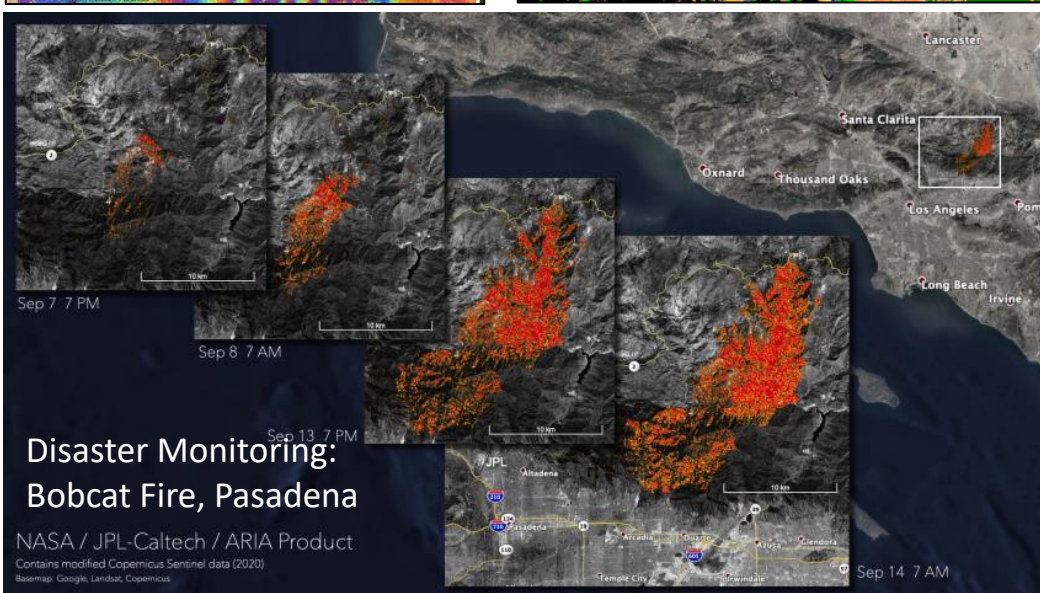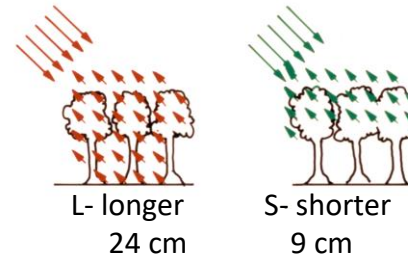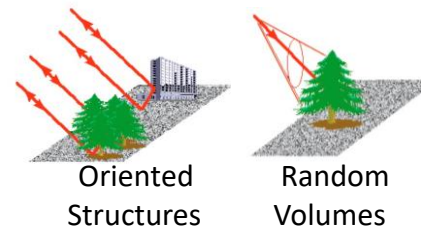
# NASA-ISRO SAR (NISAR) Mission

## Solid Earth, Ecosystems, Cryosphere Science and Applications Mission

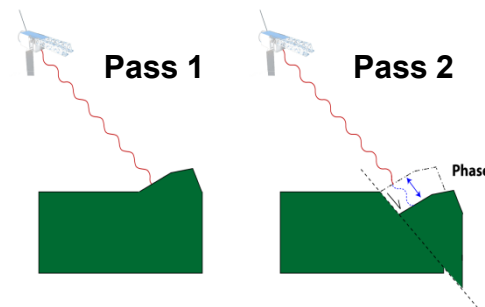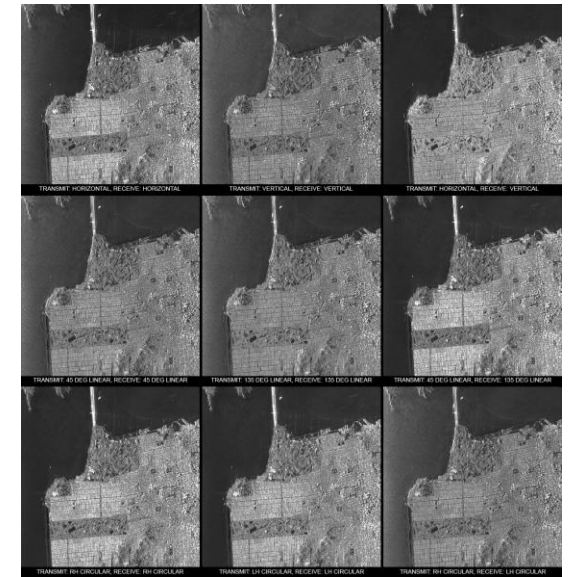| NISAR Characteristic: | Enables: |
|---|---|
| L-band (24 cm wavelength) | Low temporal decorrelation and foliage penetration |
| S-band (9 cm wavelength) | Sensitivity to lighter vegetation |
| SweepSAR technique with Imaging Swath > 240 km | Global data collection |
| Polarimetry (Single/**Dual**/Quad) | *Surface characterization and biomass estimation* |
| 12-day exact repeat | Rapid Sampling/time series |
| 3 – 10 meters mode-dependent SAR resolution | *Small-scale observations* |
| Pointing control < 273 arcseconds | *Deformation* interferometry |
| Orbit control < 500 meters | *Deformation* interferometry |
| L/S-band > 50/10% observation duty cycle | Complete land/ice coverage |
| Left/Right pointing capability | Polar coverage: north & *south* |

### L- and S-band Wavelength



L- longer 24 cm    S- shorter 9 cm

### Polarimetry



Oriented Structures    Random Volumes

### Repeat Pass InSAR



Pass 1    Pass 2

Phase

### Polarimetric Diversity



### Repeat Pass Interferometry



Radar in space

First Pass, time $t_1$

Second Pass, time $t_2$

SP – Single Pol
DP – Dual Pol
QP – Quad Pol

Greenland
80MHz SP
LSAR

Greenland
25MHz CP &
37.5MHz HH
SSAR

Sea Ice 5MHz

Background Land
20MHz DP

North America
40MHz DP & QP

Background Land
20MHz SP
Descending direction
Alternating each 12 days with
Africa and South America

Global
Urban Areas
40MHz DP

Coverage of India
Region with
LSAR & SSAR

Sea Ice Quadrant
with LSAR & SSAR

Antarctica
40&80MHz SP
LSAR

Antarctica
25MHz CP &
37.5MHz HH
SSAR

Sahara
5 MHz QD HH/VV

# NISAR Operations Overview

**SNWG Users**

**Amazon Web Services**
**Science Data Processing (JPL)**
**and**
**Data Archive & Distribution (ASF DAAC)**

Science Data Products

**Near Earth Network**

NEN Data Acquisition Processing and Handling Environment (DAPHNE)

**NEN Ka Stations**
Fairbanks, Svalbard, Wallops, Punta Arenas

L-SAR Data & Telemetry & GPS

**L-SAR Data**
*Up to 4 Gb/sec; ~27 passes/day*
*35 Tb daily average volume*
*(including 9 Tb SNWG)*

Engrg Telemetry & GPS

Reference Observation Plan (6 mon updates)

**L-SAR Radar Payload Operations (JPL)**

Urgent Response Requests

Sun-synchronous frozen orbit
747±20 km altitude
6 PM mean local descending node
100 minute period
12 day repeating ground track

S-band TT&C
Uplink 4 Kbps
Downlink 4 & 32 Kbps

*Mauritius, Lucknow, Bangalore, and Antarctica*

Engrg Telemetry

Coord Obs Plan Radar Payload Commanding & Ka-band Scheduling

Maneuver Design

**ISRO Mission Operations (ISTRAC) (Bangalore)**

**ISRO S-Band Stations (ISTRAC)**

**S-SAR Operations Support (SAC) (Ahmedabad)**

**S-SAR Data**
*Up to 2.9 Gb/sec; 8 passes/day*
*8 Tb daily average volume*

**NASA & ISRO Joint Science Team**

**S-SAR Data Processing Archive (NRSC) (Hyderabad)**

Science Data Products

S-SAR Data & Telemetry

**ISRO Ka–band Stations (Shadnagar, Antarctica)**

2.8 m

Alaska

ALOS L-band image

Oklahoma



Cal/Val Sites
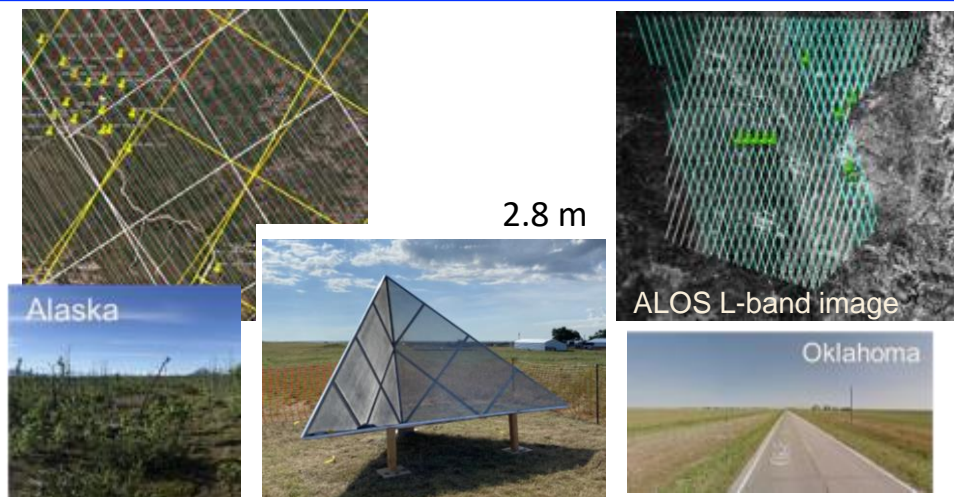
## Instrument

- Image calibration schedule during service 'commissioning' phase and the first 5 months of operation
- Corner Reflector Sites in Oklahoma, Alaska, & India
- UAVSAR phase calibration plan is being developed

## Science Cal/Val

- Each science discipline developed a Cal/Val plan for their Level 3,4 activities.

- Ecosystems: there are >100 Cal/Val sites globally and include collaborations with ISRO, NASA ABoVE, NSF NEON, University of Oklahoma, Alaska Satellite Facility, UNAVCO, NSF GAGE, University of Nevada Reno, JECAM, ESA Biomass, US Dept of Ag.

- *Validation scientific requirements workflow will be available in Jupyter notebooks*
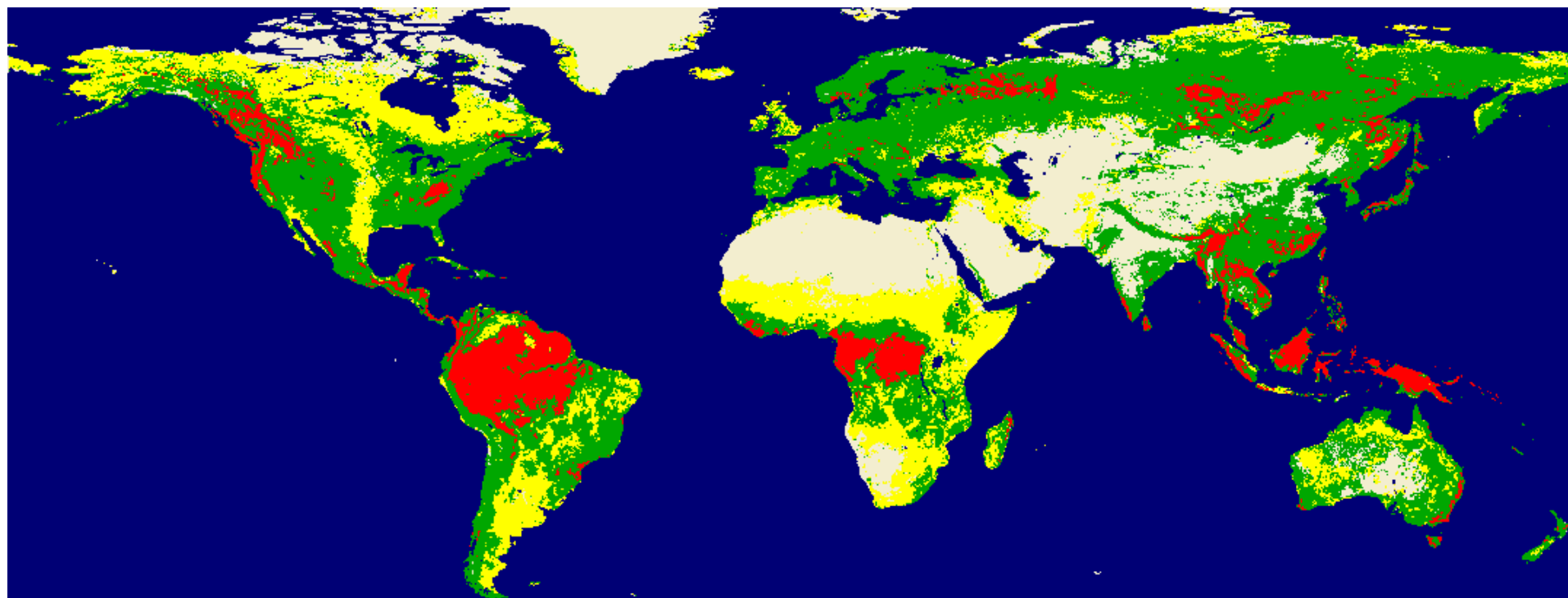
The global distribution of regions dominated by with woody biomass < 100 Mg/ha

Regions with AGB < 100 Mg/ha 50% of area

Regions with AGB > 100 Mg/ha 50% of area

Regions with AGB < 20 Mg/ha 50% of area
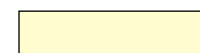
Regions with No woody vegetation

Open Water

**NISAR frequent SAR observations and spatial resolution will allow monitoring crop areas globally**

- Crops cover 11% of the Earth's land surfaces and are expanding regionally in response to climate change and food security.

- Identification of crop area is a precursor to crop classification and allows basic monitoring of agricultural resources and outputs.

- Changes in observed radar backscatter from NISAR time series data throughout the growing season is an indicator of active landcover management & crop area.
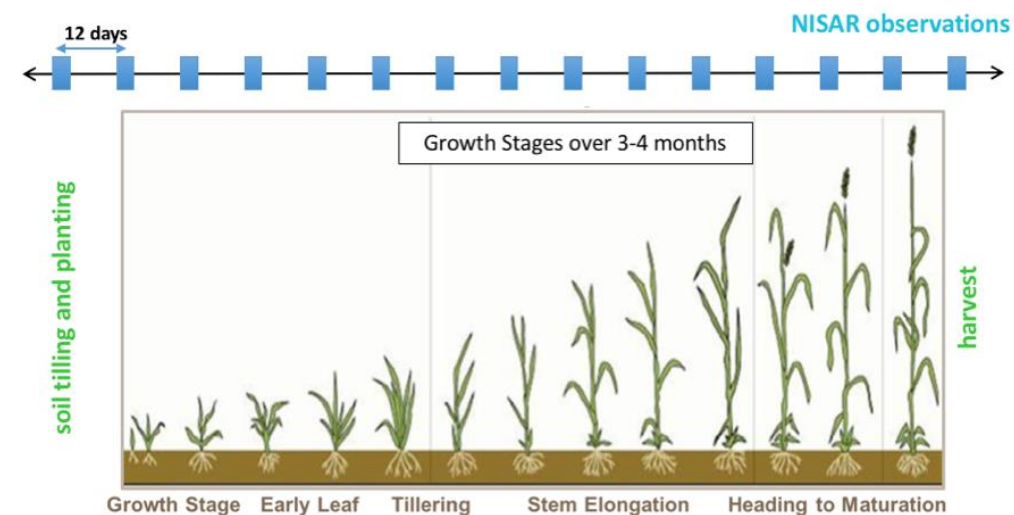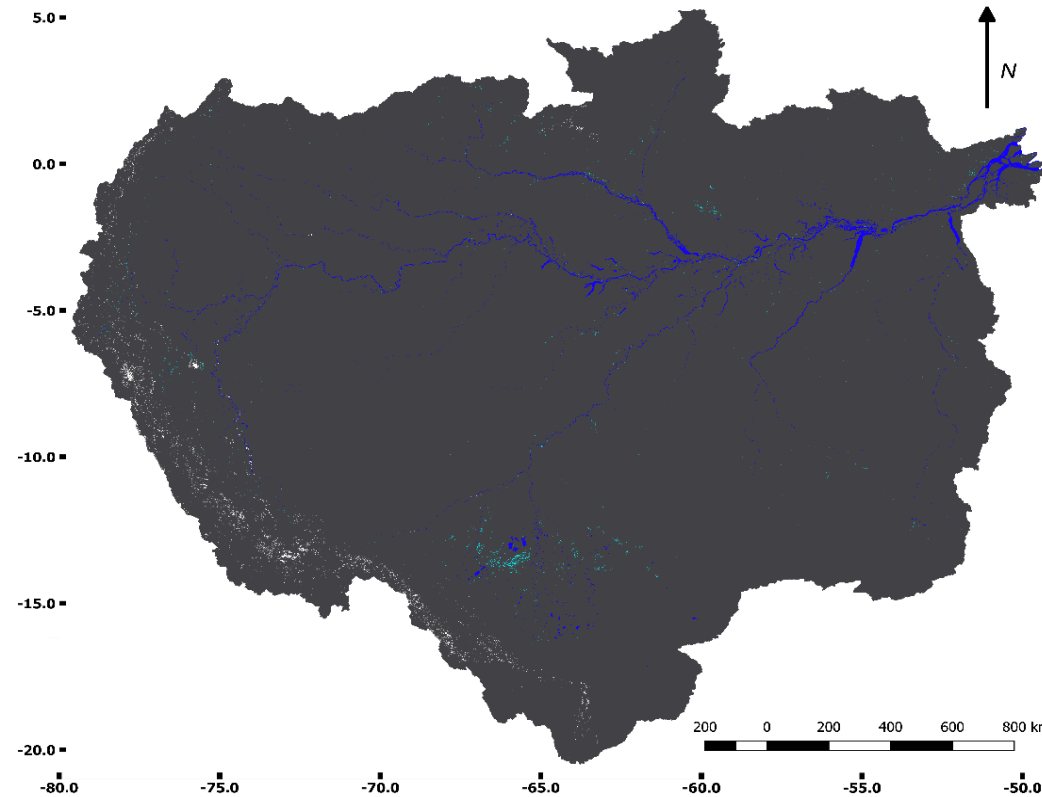


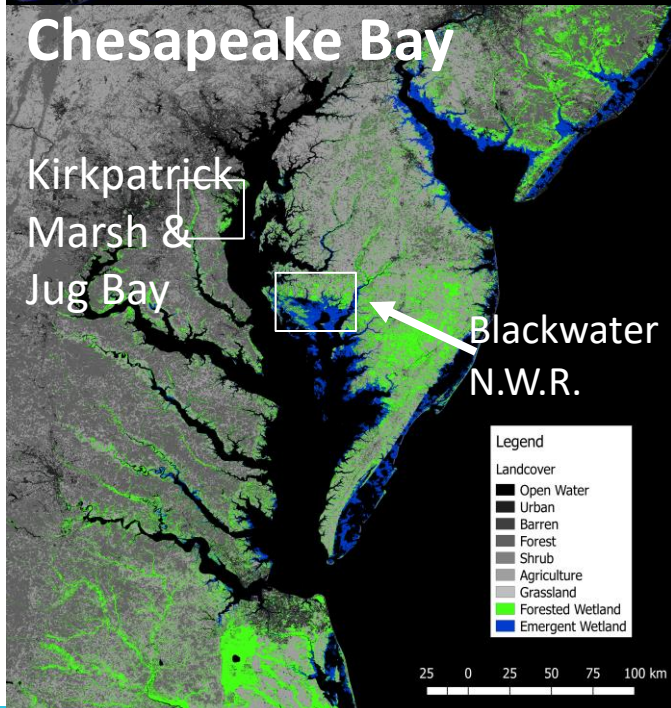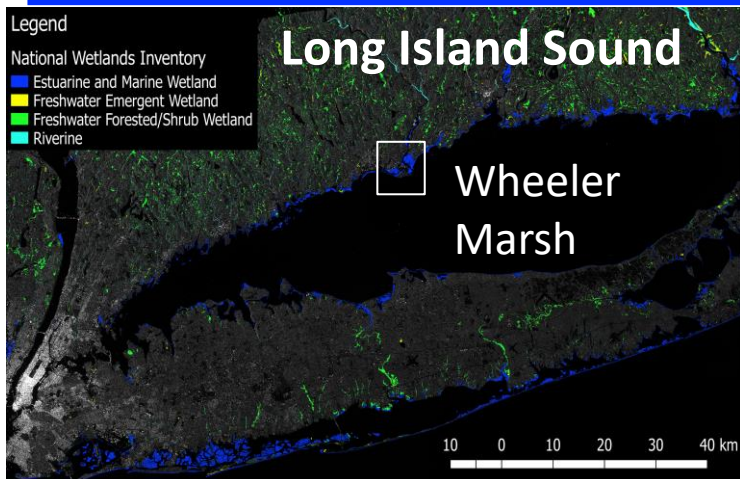**Coefficient of Variation**
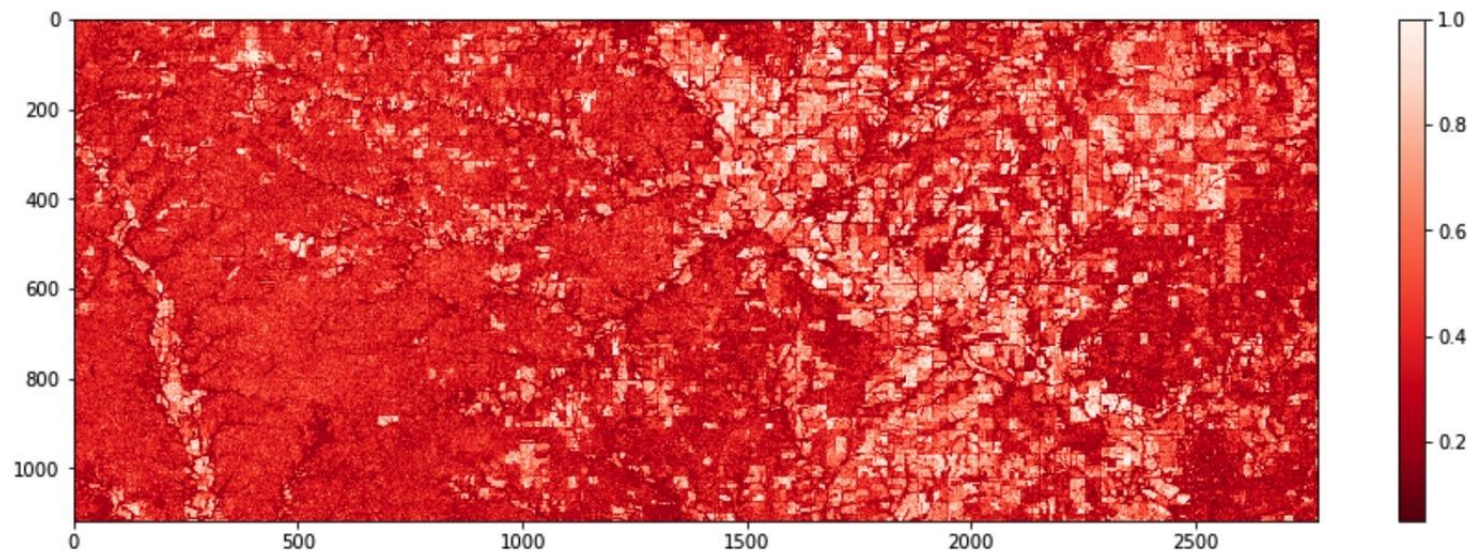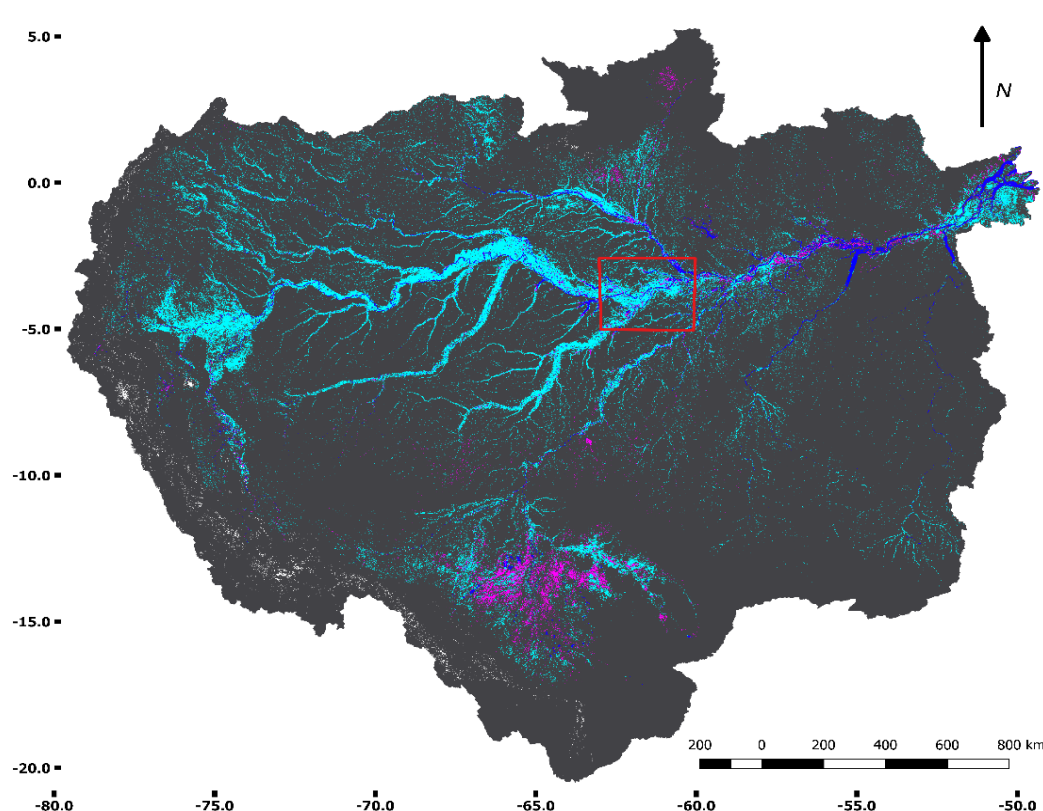
**2014/2015 maximum inundation extent**

**2015/2016 minimum inundation extent**

Light blue: inundated vegetation
Purple:     submerged vegetation
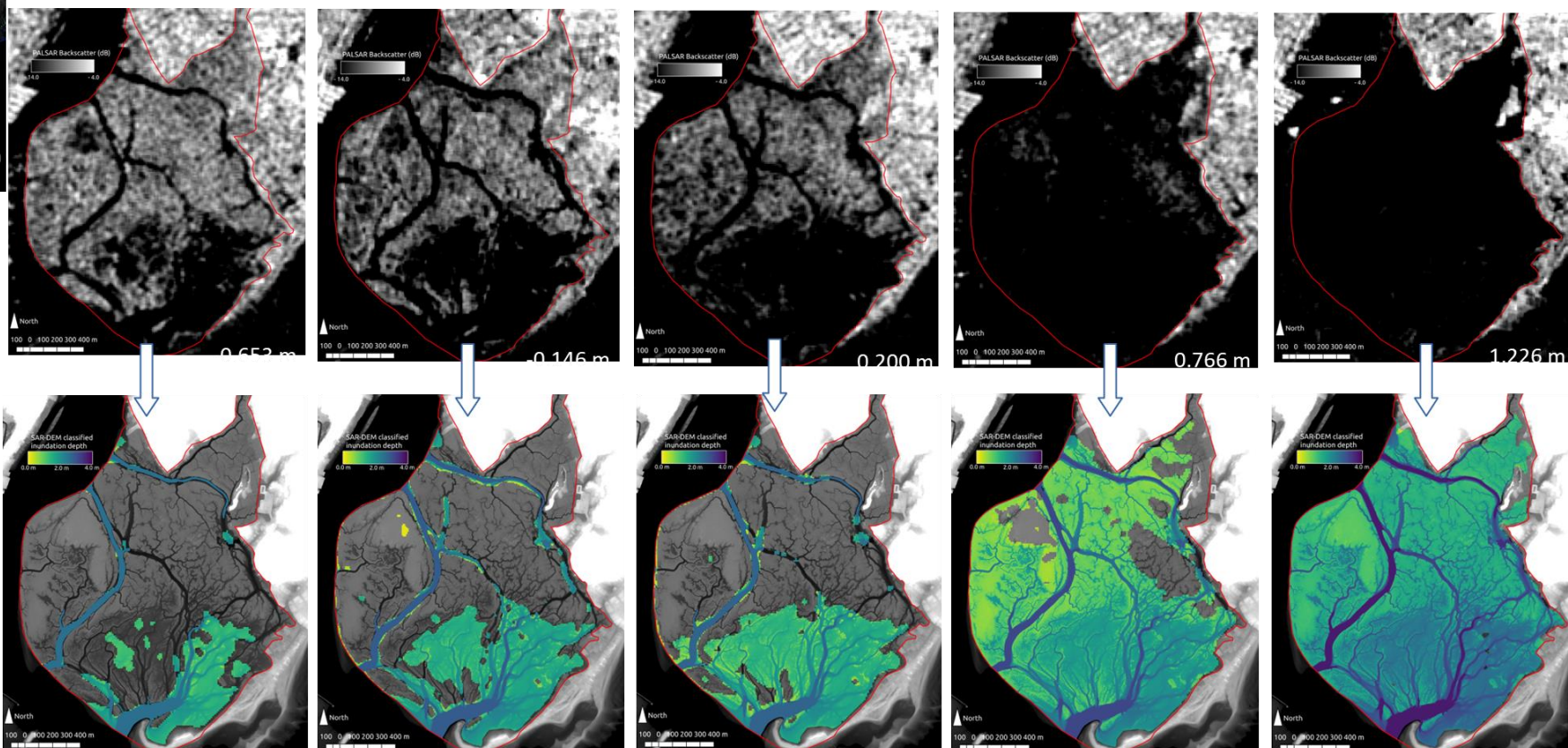Blue:       open water

Grey:     non-flooded
White:    no data

Rosenqvist et al., 2020.

# Wheeler Marsh Inundation product validation with water level sensors

PALSAR/PALSAR-2 HH Backscatter Imagery (ordered by increasing tidal stage)

* colored pixels representing water depth. Precision DEM supports inundated volume assessment

OIL SPILLS

COASTAL RESILIENCY

FIRE

FOOD SECURITY

TEXAS

ICE

SUBSIDENCE

INDUCED SEISMICITY

DROUGHT

LEVEES & DAMS

FLOOD

PERMAFROST

FORESTS

FLORIDA

VOLCANO

**Launch Window Opens January 29, 2024**

**Satish Dhawan Space Center, India**

*March 6th*